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WASHINGTON, D.C. 20460

OFFICE OF
PREVENTION, PESTICIDES
AND
TOXIC SUBSTANCES

Memorandum

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SUBJECT: Benefits assessment for diazinon use in lowbush and highbush blueberries

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Summary of Analysis

Diazinon is a potentially important (but currently minor) pest management input for U.S. blueberry growers. Elimination of this chemical on blueberries could result in some impact on efficient pest management in some regions of production, but not others. The immediate economic impact of the loss of diazinon on yield or quality loss is estimated to be low, given the alternatives likely to be available for the next four to five years. The impact of loss on pest management is more complex and depends on which alternatives continue to be available, as well as which growing region and blueberry type is considered. There are two primary types of blueberries grown in the U.S., lowbush and highbush. The production of lowbush blueberries occurs almost entirely in Maine, while highbush blueberry production occurs primarily in three regions: the Pacific North (Oregon and Washington), the North Central (Michigan and Indiana), and the East (New York, New Jersey, Florida, Georgia, North Carolina, Alabama, and Arkansas). The following analysis provides an overview of U.S. blueberry production, the role of diazinon in blueberry production, and a discussion of the impacts of eliminating (by phase-out) diazinon on lowbush and highbush blueberries. For highbush blueberries, only the largest producing states - Michigan, Indiana, New Jersey and North Carolina are considered in this assessment, due to the time constraints on this analysis.

Scope and Limitations of the Assessment

The scope of this analysis includes an examination of potential regional-level impacts associated with elimination (through a phase-out) of the use of diazinon in blueberries. This mitigation scenario reflects the high health risks to mixers, loaders and applicators as identified by the Health Effects Division of the Office of Pesticide Programs. This analysis does not attempt to address impacts associated with mitigation efforts targeted at workers reentering fields treated with diazinon, or potential mitigation for various environmental risks (e.g., risk mitigation for risks to terrestrial plants and organisms or water contamination).

The impacts estimated by this analysis only represent potential short-term-1 to 5 years - impacts on the blueberry production system. Estimates of yield and quality losses used in this assessment are based on the best professional judgement of BEAD analysts because they were not available from other sources. These estimates were derived from reviewing available USDA crop profiles, state crop production guides, discussions with university extension and research entomologists knowledgeable in blueberry production, and other sources listed.

Background of U.S. Blueberry Production

Blueberries are one of only two commercially cultivated fruit crops that are native to North America; cranberries are the second. Although wild blueberries were used extensively by indigenous people and early European settlers, they are among the most recently domesticated fruit crops. North America is the world's leading blueberry producer, accounting for nearly 90% of world production at the present time. Cultivated blueberries are grown in more than 30 states as well as in British Columbia. Nearly half of the cultivated blueberries grown are sold as fresh blueberries. Fresh blueberries are available for nearly eight months of the year from producers across the U.S. and Canada. Three major cultivated types of blueberries exist: the lowbush blueberries of Maine and eastern Canada, the highbush blueberries native to the eastern U.S., and the rabbiteye blueberries of the deep South. Hybrids between these groups are also grown commercially.

The lowbush blueberry (*Vaccinium angustifolium*) is harvested from managed wild stands in the eastern provinces of Canada and the northeastern U.S. Maine is the largest single producer of lowbush blueberries. The highbush blueberry (*V. corymbosum*) is the major cultivated species in North America. It occurs in native stands from southern Nova Scotia west to southern Wisconsin and south along the Atlantic coast and to eastern Texas. The rabbiteye blueberry (*V. ashei*) is grown in the southeastern U.S. with production in Georgia, North Carolina and several other states. There are over 70,000 acres of blueberries grown in the U.S. (includes all 3 types).

Lowbush blueberry production and cultural practices

Maine produces 98% of the wild blueberries (lowbush) in the U.S. harvested from 23,693 acres (in 1997). There are 30,000 additional acres of non-bearing lowbush blueberries each year (see Table 1 in Appendix). Total acreage is put into production in alternating years on a rotating basis. Nearly all of the harvested crop is processed (99%). Wild blueberries are grown on fields that have been developed from native plants that occur naturally in the understory of the forest. Lowbush blueberries are not planted, growers manage native stands for harvest. There are actually two species of lowbush blueberries in production in Maine. *V. angustifolium* is the most abundant and is known as the low sweet blueberry, with plants varying in height from four to 15 inches tall. The other lowbush species, *V. myrtilloides*, also known as the sour top blueberry, tends to be more prevalent in mountains or hilly areas and grows from six to 24 inches tall. Because of pruning practices employed (burning and mowing) every other year, only half of the acres are available for harvest each year (USDA Crop Profile for Maine, Aug 1999). In the growing season immediately following the pruning, the vegetative and formative growth takes place. Flower buds are formed during May with bloom lasting from 2 to 4 weeks. Blueberries require cross pollination for a successful fruit set. After pollination and fruit set, the blueberries develop and ripen for harvest in late July and August. Lowbush blueberries are harvested generally beginning at the end of July and can extend through Labor Day.

Highbush Blueberry (Including Rabbiteye) Production and Cultural Practices

The production and cultural practices of highbush and rabbiteye blueberries are similar and for the purposes of this analysis will be considered together. Rabbiteye blueberries are phenotypically very similar to highbush varieties, but have smaller berries and are more suited to southern U.S. regions where winters are more moderate. Approximately 40,000 acres total of highbush and rabbiteye blueberries are in production in the U.S. Production is separated into 3 regions, North Central (MI, IN), East (NY, NJ, GA, NC, FL), and Pacific North (OR, WA) (see Table 2 in Appendix). On average, the East region produced 40% of the highbush blueberries followed closely by the North Central region with 39% and the Pacific North with 21%. Rabbiteye blueberry production is in the South, primarily in Georgia, Florida, and North Carolina, with approximately 6,200 acres in production in 2000. North Carolina and Georgia produce both highbush and rabbiteye blueberry types.

Blueberries require fairly specific soil and climatic conditions for optimal production. Two-year old plants are generally established 3 to 5 feet apart in rows 10 to 12 feet apart. No crop will be harvested for the first two years and fields will produce increasingly larger crops until full production is reached 8 to 10 years after establishment. Well-maintained blueberry bushes remain productive for at least 15 to 20 years. Mature plants range in height from less than 3 feet for certain hybrids to 6 to 8 feet for most common commercial highbush varieties. Irrigation is important because blueberry root systems are shallow and lack root hairs; this puts them at a disadvantage when soils dry out. Overhead irrigation is also important to mediate spring frosts. Spring frosts are probably the major factor in determining the total production of blueberries for a region in any given year. Annual pruning of dead wood and older canes maintains plant vigor, reduces fruit numbers, permits light penetration, eliminates disease inoculum, and reduces populations of certain mite and scale pests. Pruning most often occurs in the winter months or in early spring.

The harvest period for highbush blueberries extends for upwards of 6 weeks with 3-5 consecutive harvests on as short as 5-day intervals. The harvest season depends on a number of factors with the most important being the variety and the climate of a particular production area. The harvest season begins about May 10 in North Carolina, June 10 in New Jersey, July 5 in Oregon and Washington, and July 10 in Michigan. In the East region, where greater than 70% of the crop is sold in the fresh market, hand picking is predominantly used. The remaining production is sold on the process market (<30%) and is generally machine harvested. The reverse is true in the North Central and Pacific North regions where 70% of production is processed and generally machine harvested and 30% is hand harvested for the fresh market. Most acreage is hand harvested for the first several pickings with the later harvests generally done by machine. Therefore, essentially 100% of the highbush blueberry acreage is both hand harvested and machine harvested.

United States highbush blueberry production and value of production by end use market for the major regions and states in these regions is listed in Table 3 (Appendix). Total U.S. production is fairly evenly split between fresh and processed, with 44% for the fresh market and 56% for the processed market. This is not the case for each region - the destination of production in the East region averages more than 67% for the fresh market and 33% for the processed market, and the destination of production for the North Central and Pacific North regions is just the opposite, with 70% or more destined for the processed market and 30% or less destined for the fresh market.

The pest management value, usage of diazinon, and the possible pest control and economic impacts of its loss are summarized below. Assessments of lowbush and highbush blueberries are presented separately.

Lowbush blueberries - diazinon usage, pest management value, alternatives, and impact of loss on pest control

On average, diazinon is applied to only about 2% of U.S. lowbush blueberry acreage (Table 4 in Appendix). Its use is mainly targeted against thrips (*Franklinella vaccinii* and *Catinathrips kainos*). These insects feed on young leaf tissue throughout the season and can reduce yield by stunting leaf maturation. Most diazinon use is made in the early part of the season. However, populations rarely build up to economically damaging levels, and an effective alternative pesticide, malathion, is used at least as often as diazinon is, according to Dr. D. Yarborough and Dr. F. Drummond, University of Maine (personal communication). These crop experts also speculated that the loss of diazinon could result in a slight increase in application costs, as they estimated malathion to be somewhat more expensive and would need to be applied more often to achieve a similar level of efficacy. However, our economic analysis indicates that the cost impact of replacing diazinon with malathion would be negligible. Using Table 4 (Appendix) for acres treated and Table 6 (Appendix) for costs per acre, the cost of diazinon on 500 acres assuming one application would be $4950 while the cost of malathion on those same acres but assuming two applications would be $4870. Thus, current costs associated with increased malathion use are at least equivalent to those involved in diazinon. Thus, as long as malathion use is preserved, growers can reasonably be expected to adapt to the absence of diazinon with negligible negative impact on lowbush blueberry pest control or economic production.

Highbush (including rabbiteye) blueberries - diazinon usage, pest management value, alternatives, and impact of loss on pest control

Diazinon is used in highbush blueberries in Michigan, Indiana, and New Jersey for the control of a variety of insect pests throughout the growing season. In the north central states, it is used to control plum curculio beetles (*Conotrachelus nenuphar*), aphids (various species), thrips (*Franklinellia vaccinii*), blueberry maggot (*Rhagoletis mendax*) as well as the blueberry tip borer (*Hendecaneura shawiana*), oblique-banded leafroller (*Choristoneura roseaceana*), and cranberry fruitworm (*Acrobasis vaccinii*), all of which are moth larvae. Alternative insecticides include azinphos-methyl, phosmet, and carbaryl for the plum curculio. In addition to these, phosmet and tebufenozide are available against moth larvae. Thrips can be controlled with either azinphos-methyl or spinosad. Aphids and blueberry maggot are similar in that there is currently only one alternative to diazinon available - methomyl against aphids and malathion for maggots (Michigan State University Pesticide Spray Guide 2001). Of all the alternatives listed here, azinphos-methyl is likely to be the most widely used substitute in the event of a loss of diazinon, as it has the widest spectrum of effectiveness. Growers with severe aphid pressure are likely to be particularly sensitive to the absence of diazinon, as methomyl cannot be used on “U-pick” fields which are open to the general public (Dr. R. Isaacs, Michigan State University, personal communication).

In New Jersey, diazinon has been primarily used against plum curculio, cranberry weevil (*Anthonomus musculus*), aphids, leafhoppers, leafrollers, and fruitworm pests (Dr. S. Polavarapu, Rutgers State University, personal communication). The list of available alternatives matches that described above for the north central regions. Insecticides active against plum curculio will also act against the cranberry weevil (which is currently a major pest only in this region). In addition, growers in New Jersey have imidacloprid as an alternative to use against aphids. Taken together, this suggests less reliance of diazinon in this region as compared to North Central states. However, if azinphos-methyl is also eliminated, growers may find it harder to control early season weevil infestations since phosmet and carbaryl, the other alternatives, do not have as long a residual activity (Dr. S. Polavarapu, Rutgers State University, personal communication).

In North Carolina and other growing regions in the south, virtually all diazinon use targets fire ants and their mounds, which are sporadic but sometimes severe nuisance pests. They interfere with worker activities in blueberry fields, particularly hand harvesting (Dr. J. Meyer and Dr. K. Sorensen, North Carolina State University, personal communication). There are currently no alternatives available for this use of diazinon. Thus, while there are no direct yield losses expected from the loss of diazinon in this region, there may be losses due to the inability to harvest and maintain fields (e.g., with hand pruning) in a timely manner. There are also losses possible due to liability costs growers may face from workers who are injured by fire ants (Dr. J. Meyer and Dr. K. Sorensen, North Carolina State University, personal communication). The economic impact of these losses are very difficult to assess accurately at this point, as there have been no estimates of the extent of fire ant impact on these worker activities or the liability extent involved. Therefore, an analysis of economic impact of the loss of diazinon use against fire ants is not included in this document. Nevertheless, since fire ant injury can be severe (even resulting in death), this use of diazinon has potential importance interms of public health protection that should be kept in mind wen considering its benefits.

Economic impacts of eliminating diazinon in highbush (excluding rabbiteye) blueberry production

Michigan and Indiana

Table 6 (Appendix) gives estimated alternative treatments and their chemical costs in this region for highbush blueberries, together with estimated cost impacts of eliminating diazinon treatments. Estimated impacts shown are for replacement of diazinon with azinphos-methyl (which targets plum curculio, moth larvae, thrips and/or blueberry maggot), with carbaryl (which targets plum curculio and/or moth larvae), with methomyl (which targets aphids), with phosmet (which targets blueberry maggot), and with a composite of all listed alternatives.

All impacts are relatively small because usage of diazinon is small (5% or less of the acreage treated and 1,500 acre-treatments or less; see Table 6). For instance, replacement of diazinon with azinphos-methyl on those acres increases total treatment costs for North-Central highbush blueberries only by about $300 (over the entire region), because of a slightly higher cost per acre of azinphos-methyl over diazinon. Similarly replacement of diazinon with methomyl increases total treatment costs by $22,000 or less, while replacement with phosmet, carbaryl or a composite of alternatives has essentially no impact. (The data actually indicate cost decreases for replacement of diazinon with phosmet or carbaryl because of their lower prices, but such decreases could be at least partially due to inaccuracies in the data, especially the price data.)

New Jersey

Table 7 (Appendix) gives estimated alternative treatments and their chemical costs in New Jersey for highbush blueberries, the major producer of highbush blueberries and the major user of diazinon in the East region, together with estimated cost impacts of eliminating diazinon treatments. Estimated impacts shown are for replacement of diazinon with azinphos-methyl (which targets weevils), with phosmet (which also target weevils) and with a composite of all listed alternatives.

All impacts are relatively small because prices of azinphos-methyl, phosmet and most other alternatives are less than that of diazinon. Replacement of diazinon with azinphos-methyl, phosmet or a composite of alternatives on 5,200 diazinon acre-treatments gives essentially no impact. (The data actually indicate cost decreases for replacement of diazinon with each of these because of their lower prices, but such decreases could be at least partially due to inaccuracies in the data, especially the price data).

Sources

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Appendix

Table 1. Maine Wild (Lowbush Blueberry) Production and the Value of Production by End Use [1, 2, 3]

Region	Harvested Acreage (Acres)	Production (1000 Pounds)			Value of Production ($1000)		
		Total	Fresh	Processed	Total	Fresh	Processed
Maine	23,693	84,097	357	83,741	$33,855	$441	$33,414

1. Sources: USDA/NASS Noncitrus Fruits and Nuts 2001 Preliminary Summary, and USDA/NASS 1997 Census of Agriculture.
2. According to USDA's Maine crop profile, Maine produces 98% of U.S. lowbush blueberries.
3. Acreage is for 1997, while production and value are 1999 - 2001 averages

Table 2. Highbush Blueberry Production and the Value of Production in the U.S. by Region and Major State in each Region[1]

Region/State	Harvested Acreage (Acres)	Production (1000 Pounds)	Percent of U.S. Production	Percent of Region Production	Value of Production ($1000)
U.S.	40,077	183,823	–	–	$165,175
North Central Region[2]	17,620	71,933	39%	--	$55,932
Michigan	16,900	69,667	38%	97%	$53,705
East Region [3,4]	17,990	72,660	40%	–	$81,217
New Jersey	7,467	36,667	20%	50%	$36,473
New York	700	1,667	1%	2%	$1,771
Florida	1,333	2,450	1%	3%	$10,392
Georgia	4,533	15,667	9%	22%	$14,027
North Carolina	3,233	14,667	8%	20%	$16,820
Pacific North Region	4,467	39,230	21%	--	$28,026
Oregon	2,700	26,467	14%	67%	$18,398
Washington	1,767	12,763	7%	33%	$9,628

1. Source: USDA/NASS Non-citrus Fruits and Nuts 2001 Preliminary Summary.
2. States in the North Central region include (% of U.S. production, % of regional production): Indiana (1%, 3%).
3. Rabbiteye production on approximately 6,200 acres in the East Region. Estimates include both highbush and rabbiteye blueberry production (Georgia (89% rabbiteye, 11% highbush); and North Carolina (75% highbush, 25% rabbiteye).
4. Other States in the East region include (% of U.S. production, % of regional production): Alabama (0%, 1%), Arkansas (1%, 2%).
5. Estimates are 1999 - 2001 averages.

Table 3. Highbush Blueberry Production and the Value of Production in the U.S. by End Use Market for each Region and Major State in each Region [1, 2]

Region/State	Production (1000 Pounds)			Value of Production ($1000)		
	Total	Fresh	Processed	Total	Fresh	Processed
U.S.	183,823	81,367	102,457	$165,175	$100,035	$65,140
North Central Region [3]	71,933	21,133	50,800	$55,932	$23,462	$32,470
Michigan	69,667	19,667	50,000	$53,705	$21,810	$31,895
East Region [4]	72,660	48,433	24,227	$81,217	$64,744	$16,473
New Jersey	36,667	27,000	9,667	$36,473	$29,257	$7,217
New York	1,667	1,583	83	$1,771	$1,717	$54
Florida	2,450	2,100	350	$10,392	$10,127	$265
Georgia	15,667	6,000	9,667	$14,027	$7,760	$6,267
North Carolina	14,667	10,333	4,333	$16,820	$14,257	$2,563
Pacific North Region	39,230	11,800	27,430	$28,026	$11,829	$16,197
Oregon	26,467	9,133	17,333	$18,398	$8,334	$10,063
Washington	12,763	2,667	10,097	$9,628	$3,495	$6,133

1. Source: USDA/NASS Non-citrus Fruits and Nuts 2001 Preliminary Summary.
2. Production by end use market not separated into highbush and rabbiteye blueberries. Estimates are only for highbush blueberries.
3. Other states in the North Central region include: Indiana.
4. Other states in the East region include: Alabama, Arkansas.
5. Estimates are 1999 - 2001 averages.

Table 4. Usage of Diazinon on Maine Lowbush Blueberries [1]

Active Ingredient	Percent of Crop Treated	Base Acres Treated (1000 acres) [2]	Total Pounds Applied (1000 lbs)
Diazinon	2%	0.5	0.4

1. Source: National Center for Food and Agricultural Policy database (1995).
2. Base acres treated calculated using percent of crop treated estimates and harvested acreage from Table 3.

Table 5. Usage of Diazinon on Highbush/Rabbiteye Blueberries by Region and Major State, 1992-1999 [1]

Region/ State	Percent of Crop Treated	Base Acres Treated (1000 acres) [2]	Use Rates (lbs. a.i./A/yr.)	Average # of Applications/Yr.	Total Pounds Applied (1000 lbs)
U.S.	16%	6	1.5	1.7	9
North Central Region	<5%	<1	NA	NA	NA
Michigan	<5%	<1	NA	NA	NA
East Region	18%	3	NA	NA	NA
New Jersey	35%	3	0.86	2.0	5
New York	2%	<1	4.0	NA	<1
Florida	NA	NA	NA	NA	NA
Georgia	2%	<1	1.0	NA	<1
North Carolina	5%	<1	0.5	NA	<!
Pacific North	22%	1	0.8	NA	1
Oregon	28%	1	0.8	1.0	1
Washington	14%	<1	0.7	NA	<1

1. Sources: USDA/NASS Agricultural Chemical Usage 1999 Fruits and Nuts Summary and 1997 Fruits Summary, USDA New York Crop Profile for Blueberries, and National Center for Food and Agricultural Policy database for circa 1997.
2. Base acres treated calculated using estimates of percent of crop treated and harvested acreage.
3. NA = information not available in EPA databases.

Table 6. Estimated Treatments of North-Central Blueberries and Cost Impacts of Losing Diazinon[1]

	% Crop Treated	Acre-Treatments (000)	Chemical Cost ($/acre)	Expenditures ($000)	Expenditure Increase ($000)
Azinphos-Methyl	76%	20.6	$10.11	$208.5	
Bt	17%	4.1	$16.22	$66.0	
Carbaryl	32%	9.7	$7.26	$70.5	
Malathion	66%	25.0	$4.87	$121.8	
Methomyl	47%	11.6	$24.82	$287.8	
Phosmet	57%	18.9	$7.02	$132.8	
Diazinon	5%	1.5	$9.90	$14.8	
Total of above		91.4	$9.87	$902.1	
Total without Diazinon		89.9	$9.87	$887.3	
Substitution for Diazinon --					
- Azinphos-Methyl		1.5	$10.11	$15.1	$0.3
- Carbaryl		1.5	$7.26	$10.9	($4.0)
- Methomyl		1.5	$24.82	$37.2	$22.3
- Phosmet		1.5	$7.02	$10.5	($4.3)
- All above alternatives (*)		1.5	$9.87	$14.8	($0.0)

(*) Substitution proportional to acre-treatment allocation of alternatives.
1. Sources: USDA/NASS Agricultural Chemical Usage, 1999 Fruits and Nuts Summary and 1997 Fruits Summary.
2. Acres grown are 17,620 acres from previous Table 2
3. Alternatives with apparent usage but inadequate data not included.
4. Percent crop treated estimate for diazinon is a maximum estimate (given as <5% in Table 5).
5. One for one replacement of diazinon acre-treatments assumed.
6. Constant costs assumed.

Table 7. Estimated Treatments of New Jersey Blueberries and Cost Impacts of Losing Diazinon[1]

	% Crop Treated	Acre-Treatments (000)	Chemical Cost ($/acre)	Expenditures ($000)	Expenditure Increase ($000)
Azinphos-Methyl	39%	5.9	$7.19	$42	
Bt	9%	0.8	$9.53	$7	
Carbaryl	23%	3.7	$10.46	$39	
Malathion	32%	4.6	$8.34	$38	
Methomyl	18%	2.6	$8.80	$22	
Phosmet	37%	4.7	$8.10	$38	
Diazinon	35%	5.2	$11.04	$58	
Total of above		27.4	$8.93	$245	
Total without Diazinon		22.2	$8.43	$187	
Substitution for Diazinon --					
- Azinphos-Methyl		5.2	$7.19	$38	($20)
- Phosmet		5.2	$8.10	$42	($15)
- All above alternatives (*)		5.2	$8.43	$44	($14)

(*) Substitution proportional to acre-treatment allocation of alternatives.
1. Sources: USDA/NASS Agricultural Chemical Usage, 1999 Fruits and Nuts Summary and 1997 Fruits Summary.
2. Acres grown are 7,467 acres from previous Table 2
3. Alternatives with apparent usage but inadequate data not included.
4. One for one replacement of diazinon acre-treatments assumed.
5. Constant costs assumed.